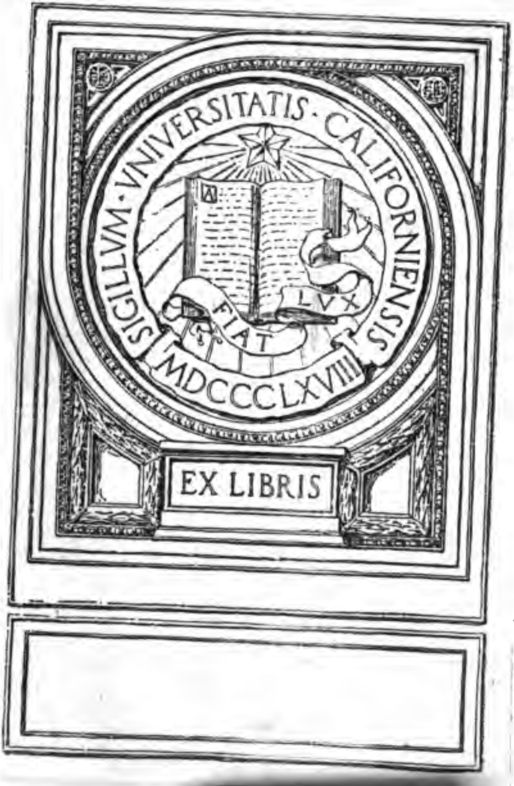
Military Map Reading

Field, Outpost and Road Sketching

BEACH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Military Map-Reading

Field, Outpost and Road Sketching

BY

MAJOR WM. D. BEACH, GENERAL STAFF U. S. ARMY,

Late Instructor in Military Topography at the United States Infantry and Cavalry School.

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PREFACE.

In the preparation of this manual constant effort has been made to treat the subject briefly, and at the same time clearly.

In the order of usefulness, as well as of instruction, "map-reading" is given the *first* place, for the reasons that it is considered more important than "map-making," that it is more easily acquired, and that "map-making" is but an application of its principles.

Military men of all grades should know how to *read* topographical maps, while comparatively few will be required to *make* any except the very simplest—viz., the field or outpost sketch and the road sketch.

The manner of using the Field or Cavalry Sketching Case (which is now an article of issue) is carefully explained, as it represents the only valuable method of hasty sketching—namely, the "plane table method."

The laborious protractor and prismatic com-

pass method of mapping directions has, for rapid work, been entirely discarded, and contours are only discussed in connection with "map-reading."

W. D. B.

Washington, January, 1904.

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PART I.

MILITARY MAP-READING.

CHAPTER I.

A *military topographical map* is a drawing or plot on which roads, woods, streams, hills, marshes and other objects of military importance are shown by conventional signs in their true relative positions.

Difference between Civil and Military Maps.

Military maps differ from ordinary civil maps in many ways; for example, a civil map might merely indicate a road, while a military map and accompanying report would show whether the road is fenced or not, as well as its width, material and condition; a civil map might only indicate the more important streams, while the other

would show *all* streams, with their width and depth; a bridge might be simply indicated in the first, while the other should show its material, size and height above water; telegraph lines, woods, hills, valleys, ridges, and gullies are omitted in the first as unimportant, while in military maps they are among the most necessary features and are usually shown.

Civil maps are, however, nearly always of very great importance in a military way, as they are often the only maps obtainable and may be made the basis for the construction of military topographical maps, thus saving much time and labor in the measurement of distances and directions.

By *map-reading* is to be understood the faculty of quickly understanding a topographical map.

Three Essential Points in Map-Reading.

In order that a person may comprehend the meaning of a map, or, in other words, *read* the map, the following points are absolutely essential:

(1) He must be familiar with the various *signs and symbols* used to designate the different objects.

(2) He must understand that *each distance* on the map is a certain fixed part of the corresponding distance on the ground—for example, if two places an inch apart on the map are a mile apart on the ground, then an inch measured any where else on the map will correspond to a mile on the ground.

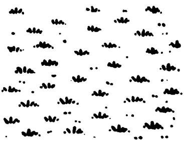
(3) He must realize that the *directions* of objects from each other on the map correspond to their actual directions from each other on the ground.

(4) Contours must convey to him a clear mental picture of the ground represented.

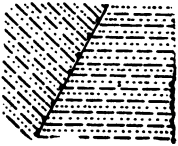
The above essentials to map-reading will now be briefly explained.

(1) CONVENTIONAL SIGNS AND SYMBOLS.

The more familiar conventional signs and symbols are the following:

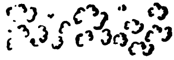


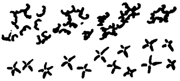
Grass or *meadow land* is shown by tufts of grass scattered irregularly over the field and all having their bases parallel to the bottom of the



map. In colors this sign is made in *green*.

Cultivated land is indicated by rows of broken lines and of dots, alternating. In colors this sign is made by ruling solid *brown* lines on a *yellow* ground.





Ordinary *forest trees* are indicated by loops grouped irregularly.

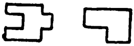
In representing *oaks* the points of the loops are outward. *Evergreen trees* are indicated by stars. *Green* is the color always used for this sign.

Orchards are shown by small tree signs with shadows, the trees being placed in rows.

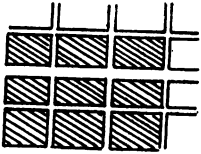
Streams are shown by single sinuous lines; dry runs by broken and triple dotted lines. *Ponds, lakes* and larger bodies of water have "water-lines," while *marshes* are indicated by parallel lines with intervals in which are placed grass signs. In colors *blue* is always used for water and

dry runs. Water-lining in colors is now seldom used, it being simpler to rub in a uniform light blue tint with pencil-scrapings and a piece of chamois.

Buildings, if of such a size that they can be readily drawn to scale, have the ground plan shown in outline. In colors *red* is always used for masonry buildings and *brown* for wooden.

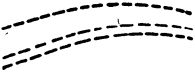


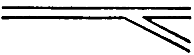
Villages and *towns* are usually indicated as shown, no care being taken to show single buildings.



Foot paths are indicated by broken lines, which in colors are made in *brown*.

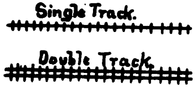
Roads, if unfenced, have a broken border; if fenced, the outline is drawn full. In colors the body of the road is made of *yellow*.



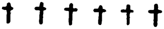


The border is *brown*, unless a particular kind of fence is to be indicated, when different colors are used: thus a road with hedges on the sides would have a *green* border; one with a wire fence, a *blue*

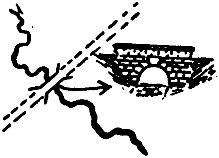
border; one with a wooden fence, a *brown* border, and one with a stone fence, a *red* border.



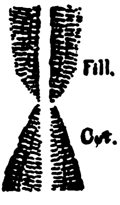
Railroads are indicated as shown. In colors they are made in *red.*



Telegraph lines are indicated by poles with cross-trees, at regular intervals. In colors they are made in *brown.*

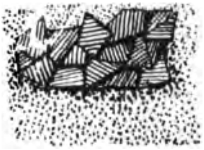


Bridges on maps are usually shown by two parallel lines for the sides with wing walls at the ends. Sometimes the details of bridges are shown by small sketches at the side of the map. In colors, a wooden bridge is made in *brown*, a stone one in *red* and a metal one in *blue.*

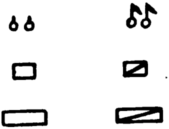


Cuts and *fills* are made by short broken lines lying in the direction of the slopes; both cuts and fills have a heavy line along the crest of the slopes and are thus easily distinguished. In colors they are made in *brown* on a *yellow* ground.

Arroyos or *gullies* are made in the same manner as cuts.



Sand is indicated by dots and *rocks* by sets of short parallel lines as shown. In colors sand is shown by a flat tint of *yellow*, and rocks are roughly indicated in *brown*.



Sentries are indicated by a circle with line pointing to the front. *Videttes* have a pennant indicated.

A *picket* is represented by a small rectangle, its *support* by a larger one.

Infantry companies and battalions are shown by plain rectangles, while for cavalry the rectangles have a diagonal line drawn across them. Artillery is shown by guns.

Hills are sometimes indicated by what are known as hachures, short lines lying in the direction of the slope; the shading is darker where the slope is steeper.

The other and usual method of representing hills and slopes, by the use of curved

lines called contours, will be explained in Chapter II.

Practice in making the foregoing conventional signs and symbols should be kept up until a fair degree of skill is acquired, by which time they will have been thoroughly learned and the next step in "map-reading" can be undertaken. When using colored pencils it will be found necessary to make the symbols larger than those shown.

(2) THE SCALE OF A MAP.

The second subject with which a person desiring to take up "map-reading" must be familiar is that of the scale of the map.

Relation Existing between Ground and Map.

A map and the ground it represents have a certain *fixed* relation to each other in respect to size; *any* distance on the map is a certain *fixed* part of the corresponding distance on the ground, and this *relation* between map and ground is the *scale of the map.* Thus, suppose the distance between two points on the map is 3 inches and it is known that

these two points are actually a mile apart on the ground; it is seen at once that 3 inches on the map corresponds to a mile on the ground and we say that the map is drawn on a scale of 3 inches to 1 mile.

This relation or ratio may be written in the form of a fraction, thus:

$$\frac{3\text{ in. (on map)}}{\text{mile (on ground)}} = \frac{3\text{ in. (on map)}}{5280\text{ ft. (on ground)}} = \frac{3\text{ in. (on map)}}{63360\text{ in. (on ground)}} = \frac{1\text{ inch (on map)}}{21120\text{ in. on ground}}$$

from which we see that 1 inch on the map equals 21,120 inches on the ground.

From the fact that this fraction ($\frac{1}{21120}$) represents the relation or ratio existing between the map and the ground, it is called the "representative fraction" or scale ratio; it always has unity for its numerator and we say that the map is drawn on an R. F. of $\frac{1}{21120}$ or on a scale of $\frac{1}{21120}$ or on a scale of 3 inches to 1 mile, all three expressions having the same significance.

Some maps have only an R. F., others have a scale constructed, while still others have both; a map without a scale is valueless.

The usual form of scale is here shown, and it may read miles, yards, feet, paces, etc., depending

upon the R. F., and the purpose for which the map is to be used.

Simplest Form of Scale for Maps.

At times, especially where a choice is allowed, the construction of a scale for a proposed map merely amounts to transferring to the map graduations found on a foot-rule, so that no actual figuring is necessary. Thus, suppose we have a sheet of drawing paper 20x22 inches in size and we wish to draw on it a map of some military reservation which we know to be about a mile square. By simple inspection we see that if an inch on the proposed map be assumed to represent 100 yards on the ground, a mile (1760 yards) will be represented on the map by a line 17.6 inches long, so that all it is necessary to do is to draw at the bottom of the sheet a line 5 inches long, mark the inch divisions (which will represent 100 yards each), and then divide the left inch into quarters, thus giving a smallest reading of 25 yards.

Ordinarily, however, the matter of scale construction is not so simple for the reason that an inch may be required to represent a fractional number of yards, feet, miles or paces, while the scale which appears on the map should, for convenience both

in making and reading the map, represent only whole units or tens, hundreds or thousands of units.

It has been found that the readiest way to become familiar with scales is to actually construct them. The problem is a very simple one in arithmetic.

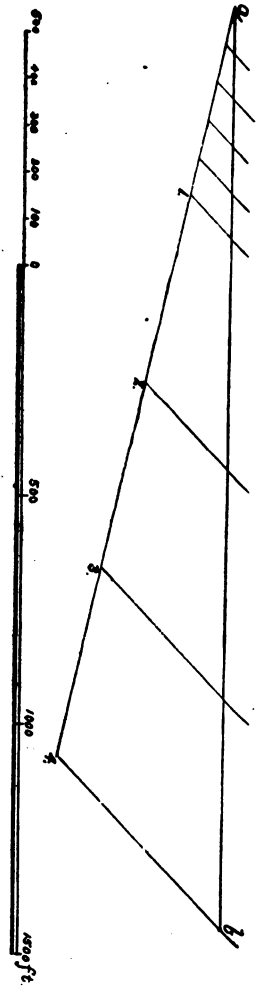
The Construction of Scales for Maps.

The *Unit of Measure* of a scale is the quantity which the main divisions of the scale read, as miles, yards, feet, etc., and must not be confused with the smallest reading of the scale. The main divisions of the scale may be subdivided without changing the unit of measure (in example shown the unit is "miles" and the smallest reading 2 miles).

As an example in scale-construction let it be assumed that a map of the reservation is to be made on a scale of $\frac{1}{5000}$ and that we have a 100-foot tape with which to make measurements.

As we must measure distances in *feet*, we naturally want a scale of *feet*, so that the problem presented is as follows—viz., *construct a scale at R. F.* $\frac{1}{5000}$, *to read feet.* The *unit of measure* we see is *feet.*

As 1 inch on the map represents 5,000 inches on the ground, it represents $\frac{5000}{12}$



or 416.67 feet on the ground. Since we want the scale about 5 inches long, we see that as 1 inch on map corresponds to 416.67 feet on ground, 5 inches on map will correspond to 5x416.67 equal 2083.35 feet on ground; but as scales are always made to read units or tens, hundreds or thousands of the units of measure, we will select for this scale a length corresponding to 2000 feet (the nearest thousand units of measure corresponding to the 5-inch length desired). Now, to find *exactly* how many inches on the map correspond to 2,000 feet on the ground, or, in other words, to find the *total length* of scale, we have only to substitute in this proportion:*

The number of units of measure represented by 1 inch	:	The selected number of units	::	1 inch	:	x the required length of scale

*This proportion should be not only thoroughly understood, but should be committed to memory, as it is used in the solution of every problem in scales.

By substituting, we have $416.67 : 2000 :: 1 : x \therefore$ $416.67x = 2000 \therefore x = 4.8$ inches.

That is to say, the entire length of the scale to show 2000 feet is 4.8 inches.

To complete the scale, lay off a line *ab* 4.8 inches long and from one extremity draw another line 4 inches long as shown, marking the inch divisions on the latter; then join *4* and *b* and from *3*, *2* and *1* draw with ruler and triangle lines parallel to *4b*, the last three lines will divide *ab* into four equal parts, each of which will represent $\frac{1}{4}$ of 2,000 feet, or 500 feet. By dividing *a1* into five equal parts and drawing lines parallel to *4b*, we get the smallest reading to be $\frac{1}{5}$ of 500 feet, or 100 feet. The completed scale would appear as shown.

If, instead of the 100-foot tape, we had only our 30-inch step with which to measure distances, it would be necessary to construct a *scale of steps*. The problem would then be: *Construct a scale at R. F.* $\frac{1}{5000}$ *to read steps, the length of one step being 30 inches.* The *unit of measure* in this case is *steps* and the solution of the problem would be as follows:

As 1 inch on map represents 5,000 inches on ground, it represents $\frac{5000}{30}$ or 166.67 steps on ground.

Five inches (about the length of scale desired) represents 5x166.67 or 833.35 steps. Select 800 steps for a total length of scale, then, from the proportion referred to above, we have 166.67 : 800 : : 1 : x. $\therefore x=4.8$ inches = total length of scale corresponding to 800 steps. The scale would be completed as before by laying off a line 4.8 inches long and from one extremity another line 4 inches long making a small angle with it. The four 1-inch divisions in the second line enable us to divide the first line into four equal parts, each of which will represent 200 steps. The left division might be divided into 8 equal parts, making the smallest reading 25 steps.

It often happens that the distances to be used in making a map have to be measured by counting a horse's steps. Experience has shown that the horse is much more reliable in measuring distances in this manner than man, so that we have but to ascertain the average length of the horse's step, by walking or trotting him over a measured distance (the longer the better) and then construct a scale in a similar manner to that above described.

In practice, when using the horse, it has been found more convenient to count strides than steps; that is, make *one* count each time the left fore foot strikes the ground.

Suppose, for example, a horse is to be used in making a road sketch at 3 inches to the mile and that, after a number of trials, we find he averages 340 strides in trotting half a mile.

The problem would be as follows:

A horse takes 340 strides in trotting half a mile; construct a scale at 3 inches to 1 mile to read strides trotting.

The *unit of measure* is *strides trotting.*

From previous explanation we know that the R. F. (found by dividing 3 inches by 1 mile) is $\frac{1}{21120}$. To find the length of one stride is very simple, for as 340 strides equal $\frac{1}{2}$ mile or 31,680 inches, 1 stride equals $\frac{31680}{340}$ inches, equals 93.18 inches. Since 1 inch on map represents 21,120 inches on ground and 1 stride equals 93.18 inches, it follows that 1 inch on map represents $\frac{21120}{93.18}$ strides, or 226.6 strides. Five inches (about the length of scale desired) represents 5x226.6 strides, or 1,133 strides. Select 1,100 strides for the total length of scale;

then, from the proportion already referred to, we have $226.6 : 1100 :: 1 : x \therefore x = 4.85$ inches, or total length of scale corresponding to 1,100 strides. The scale would be completed as before by dividing the total length into 11 equal parts, corresponding to 100 strides each, and then subdividing the left division into 4 parts of 25 strides each.

Summary of Steps in Constructing a Scale.

In the construction of *any* scale, have pencil, ruler and triangle at hand and then ask yourself the following questions, writing the answer to each:

a. What is its R. F.?

b. What is its "unit of measure"?

c. One inch on map represents how many of these "units of measure"? (Yards, feet, strides, or whatever they may be.)

d. Five inches on map represents how many of these "units of measure"?

Now, *select* the nearest 10, 100, or 1,000 units to the last number found and substitute it in the proportion.

No. of units of measure represented by 1 in.	:	Selected No. of units.	::	1 in.	:	Required length of scale.

Then, bearing in mind that the result thus found is the length of the required scale in inches, corresponding to the *selected* number of units, lay it off with the aid of the ruler and then divide and subdivide it as explained.

By following the above steps any problem in scales can be readily solved.

The subject of scales is one of the most important in both map-reading and in map-construction and it is recommended that each of the following examples be worked out and the scale carefully made.

Problem 1. Construct a scale at 10 inches to the mile to read yards.

Problem 2. Construct a scale at 6 inches to the mile to read paces of 32 inches each.

Problem 3. A horse takes 160 strides in trotting half a mile; construct a scale at 4 inches to the mile to read strides trotting.

Problem 4. Construct a scale at R. F. $\frac{1}{10000}$ to read yards.

Problem 5. A horse trots a mile in 8 minutes; construct a scale at 3 inches to the mile to read minutes trotting.

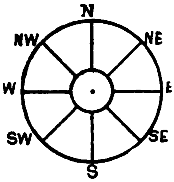
(3) THE POINTS OF THE COMPASS.

Having become familiar with deciphering ordinary objects represented on a map, and of finding their distance apart, it now follows that we must know the *direction* of one object from another or from the north. In other words, if we have a map of the surrounding country and a compass, we must be able to move from one point to another with the certainty of not becoming confused as to directions.

Method of Finding the Direction of One Point from Another on a Map.

All maps have a line marked on them to indicate the north, this line being called the meridian or needle.

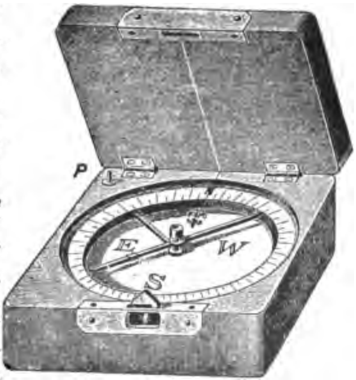
The general direction of one point on the map from a second point is very readily ascertained by think-



ing of the circle with eight of the cardinal points indicated on it. Conceive such a circle to be placed with its center at the *second* point, and with its N.-S. line parallel to the meridian on the map; whichever radius

points toward the first point will indicate roughly its direction.

For more accurate measurement of directions, however, this circle is divided into 360 equal parts, called degrees. Thus, if we suppose the 0 degree of the circle to be at the north and the circle to be graduated around by the right, we will have 90 degrees at E., 180 degrees at S., and 270 degrees at W., so that if the center of such a circle be placed on the second point referred to above and the N.-S. line be made parallel to the meridian of the map, the direction or bearing of the first point can be much more accurately ascertained.



A circular disc of metal or other substance marked as described above is called a *protractor*, and although usually cut down to a semi-circular or rectangular form, all are made on the same principle, namely, the divi-

sion of the circle into 360 equal parts, called degrees.

Directions in the field are usually determined with the compass.

The Box Compass

The ordinary form of compass, known as the box compass, is here shown; it has a light needle which swings freely and comes to rest with its north end pointing to the *magnetic* north. This compass circle is graduated from 0 at the north up to 360 in a direction contrary to the numberings on the face of a watch.

The Declination of the Needle.

The *magnetic north* differs from the *true north* in most localities, and moreover this discrepancy is constantly changing, for which reason it is evident that maps should have the true as well as the magnetic north indicated. The amount or number of degrees by which the needle points away from the true north is called the *declination of the needle* and this declination is different at different places.

Simple Methods of Determining a True Meridian.

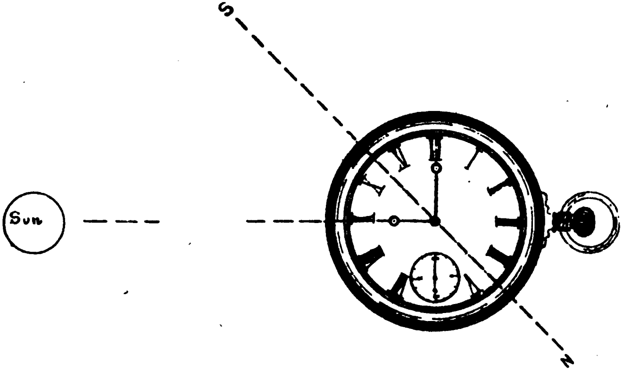
A *true meridian* (true north-and-south line) can be determined at night by aid of the North Star, which for this work may be considered as fixed in position. It is a fairly bright star and is very nearly in line with the "pointers" of the constellation known as the Great Bear or Dipper. In the figure *a* and *b* represent the pointers and *P* the Pole Star.

Without instruments the determination can be made approximately by placing two cords with weights attached in line with the star. The cords should be about 12 feet apart, and to see the forward one it will be necessary to throw the light of a lamp or candle upon it. This line can be readily prolonged by daylight.

A true meridian can be roughly determined by aid of a watch and the sun, as follows:

Lay the watch on some level surface, as a fence-post, and revolve it until the hour-hand points

directly under the sun. Then, by reference to the divisions on the dial, determine the point on it mid-



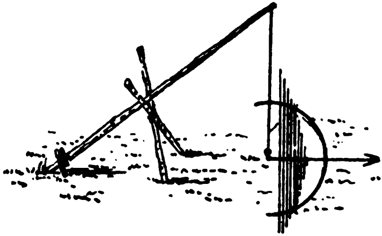
way between the hour-hand and the figure XII. This point and the pivot of the hands lie in the true meridian.

The operation of pointing the hour-hand "directly under the sun" is much simplified by casting the shadow of a vertical straw or other small object across the face of the watch and then bringing the hour-hand into this shadow.

A true meridian can be determined by aid of the sun and a plumb-bob, as follows:

On a level piece of ground lean a pole toward the north and rest it in a crotch made by two sticks

as shown. Suspend a weight from the end of the pole so that it nearly touches the ground; then, about an hour before noon, attach a string to a peg driven directly under the weight and, with a sharpened stick attached to the other end of the string, describe an arc with a radius equal to the distance from the peg to the shadow of the tip of the pole. Drive a peg on the arc where the shadow of the tip of the pole rested. About an hour after noon watch the shadow of the tip as it approaches the eastern side of the arc and drive another peg at the point where it crosses.



By means of a tape or string find the middle point of the straight line joining the last two pegs mentioned; a straight line joining this middle point and the peg under the weight will lie in the true meridian.

If a distant object as a pole be placed in prolongation of this line, one has only to go to it and

sight his compass back on the tip of the inclined pole in order to get the "declination of the needle." The declination will be "*so many* degrees east," or "*so many* degrees west," depending upon the amount the needle points to the east or west of the line of sight.

To Determine, with a Box Compass, the Magnetic Bearing of any Object.

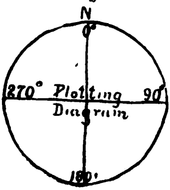
In order to ascertain in the field the magnetic bearing of *any* object, simply place the eye near the letter *S.* of the box and with the lid well back, sight toward the object along the scratched line of the cover. When the needle stops swinging, press the little pin at P and then read on the graduated circle the degree opposite the *north* end of the needle.

Should the compass ring have its S-N line perpendicular to that shown, then sight along the edge of the box-cover, the eye being at the end toward the S of the compass ring and read the north end of the needle as before.

Plotting Compass Bearings.

To plot on a map a direction or bearing which has been taken with a box compass (or for that matter, with any variety of compass), it is conve

nient to refer to a roughly drawn "plotting diagram," which may be made in pencil on the edge of the map and is merely a circle with two perpendicular diameters having their extremities appropriately lettered and numbered. To letter and number the diagram put the letter N at the end of one of the diameters (preferably the one corresponding in direction to the needle on the map), then sighting north with the compass, read the north end of the needle and record this reading under the letter N, which consider as the position occupied by the XII. on the face of a watch; next sight the compass toward the east and record the new reading of the north end of the needle on the plotting diagram at what would be the III. of the watch-face; proceed in the same manner, facing south, and then west and record the readings at the extremities of the diameters opposite those already marked.



To plot any bearing, as 25° for example, glance at the diagram and note that the line must be in the upper right quarter of the circle, so placing the center of the protracter

on the plotted position of the station from which the sighting was taken and its zero diameter or edge parallel to the map meridian, dot the twenty-fifth degree interval from the north toward the right; a line on the map through the station and this point will correspond in direction with the line on the ground having the magnetic bearing of 25°.

Similarly, if the bearing of a distant chimney were 289°, we know at once, by reference to the diagram, that its plotted direction must lie in the upper left quarter of the circle. Since in direction it lacks but 71° of being due north, place the protractor along or parallel to the map meridian with its center over the occupied station as before and pick off the required angle.*

Usefulness of the Compass.

For a soldier the compass is the most useful of all surveying instruments. Without it the map which is furnished him may be almost unintelligible even in the exact locality it represents. Without it a map such as he may be called on to make is almost an impossibility.

*The plotting diagram shown corresponds to a box compass graduated from zero at the north, contra-clockwise.

With a compass a soldier may travel by day or by night with the utmost certainty of advancing in the required direction, and should he desire to return to the starting-point, it is simply necessary to travel on the reverse bearing. For example, if on starting from camp he notes that the direction pointed out for him to take has a bearing of 25° by his compass; on returning, his line of march must differ from it by 180°; that is, he must travel in a direction shown by his compass to have a bearing of 205°.

Following a Map-Road with Assistance of Compass.

If he is furnished with a map and directed to march to a certain point by following certain roads, he may become confused and be unable to decide which of several cross-roads to take. In this case it is only necessary to spread the map out on the ground, lay the compass on it with its N.-S. edge (that is, the edge which is parallel to the N.-S. line of the circle) on the line representing the magnetic meridian, and then revolve the map carefully until the north end of the needle comes opposite the letter *N.* (or the arrow) of the box. The map is now said to be *oriented*—that is, all lines on the

map are parallel to the lines on the ground which they represent; and, in order to determine which of the several divergent roads to take, he has only to place his ruler along the proper "map-road" and by sighting along it decide at once which road on the ground corresponds to it.

Should the map *not* have a magnetic meridian marked on it, the declination of the needle should be ascertained, and, the edge of the compass box having been placed along the *true* meridian, the map should be turned until the needle points the required number of degrees to the east or west of the letter *N.* of the box, depending upon whether the declination is east or west; the orientation is now complete and there will be no difficulty in selecting the proper road to follow.

Marching Across Country on a Compass Bearing.

Occasion might arise making it necessary to travel at night across country on a compass bearing taken from a civil map. Suppose, for example, one is sent to a town fifty miles distant, which appears from the map, oriented as before described, to bear 30° to the west of magnetic north. To

start in the proper direction, it is only necessary to hold the compass in front of the face or place it on the ground and, sighting along its south-north line, turn until the north end of the needle is opposite the 330° division; the south-north line of the compass then points toward the distant town. The course is kept by occasional reference to the compass which is held as before, the body being turned to the right or left until the north end of the needle again points to the 330° mark.

CHAPTER II.

In the previous chapter maps have been studied with reference to distances, directions and objects represented; it now remains to consider them with reference to the configuration of the ground.

Forms of Ground.

The almost infinite varieties of form which ground has assumed can all be grouped under seven heads, as follows:

1. *Ridges* or *water-sheds* are merely the highest lines of the ground separating lower portions, the sky line and *NH* and *AB* in Plate I., Fig. 1, are such.

2. *Water-courses* or *valleys* are the lower portions lying between the ridges, as *C*. Varieties of valleys are ravines, gorges and cañons, the last is shown at *D*. It will be noticed that all valleys have the ground rising on three sides and falling on the fourth.

3. At a *shoulder*, *spur* or *nose*, as *S*, the ground falls on three sides and rises abruptly on the fourth.

4. *Buttes*, *peaks*, *cones*, *hills*, *knobs*, *knolls* and *mounds* have the ground falling on all sides, as at E.

5. From a *basin*, *crater*, *hole* or *pit* the ground rises in all directions, as from the bottom of the crater F.

6. *Cols* or *saddles*, *gaps* and *passes* have the ground falling on two opposite sides and rising on the other two sides, as at G.

7. If the ground were level in all directions, we would have a *plateau*, *mesa*, *table-land* or *plain*.

The country is said to be undulating or rolling when the ground, in form, resembles large waves. In a military map it is of course necessary to show these forms and features of the ground if it is to be of any use in marching troops, placing outposts, etc.

The method of representing these various forms on a map is by *contours*.

Explanation of Contours.

Suppose in Plate I., Fig. 1, the main stream has been dammed at H, the head of the lake, thus causing the water to rise 30 feet, as shown by the broken and dotted line, against the foot of the hills. It is evident that if this water-line were surveyed and plotted to scale (as might be done with a road, for example) in its correct position on a map of this section of country, it would show the true shape of the edges of the main valley and of the cañon. Now, assume the water to have risen 30 feet more and the new water-line to have been surveyed and plotted on the map and, in the same way, successive water-lines at 30 feet *vertical* intervals apart to have been surveyed and plotted, and there results a series of curved lines on the map, which are called *contours*. (Plate I., Fig. 2.)

Contours on a map may thus be defined as the plotted imaginary lines cut from the surface of the ground by equidistant horizontal planes.

Since, in surveying, all measurements are made horizontally, it is evident that the distance be-

tween contours on a map (corresponding to the horizontal distance between the successive water-lines) will be less as the slope becomes steeper.

What Contours Show on a Map.

By an inspection of the broken and dotted water-line (Plate I., Fig. 1), and its corresponding contour on the map below (contour 30, Fig. 2), together with the other contours representing successive water levels, several important points with respect to contours in map-reading become apparent—viz.:

1. All points of a contour have the same elevation above the plane of reference (which in this instance is the lake), and no two can cross.

2. Where successive contours on a map are the same distance apart, the slope is uniform.

3. Where the previous condition exists and the contours are straight, the ground is a sloping plain, as at *R*.

4. Where a ridge, as *V*, juts out into a valley, the contours curve outward or are convex toward lower ground.

5. Where a valley, as *C*, opens out into a larger valley, the contours curve inward toward the head of the small valley, or are concave toward lower ground. As streams are always found in valleys, never on ridges, it is seen that the curve of the contour shows at once the direction of flow of the water; in other words, contours always "head" up stream, as at *X* and *D*.

6. Wherever a ridge or valley exists there is, for each contour on one side of it, another on the opposite side having the same elevation (in reality two parts of the same contour, although not necessarily continuous owing to the map being limited in size; for example, the two parts of the 60, the 90 and the 120 foot contours, Plate 1, Fig. 2).

7. Resulting from the previous condition is the fact that no single contour can appear between a pair of others having the same reference.

8. Where two or more ridge contours are close together as, for example, those near "S" and adjacent ones wider apart, a shoulder or spur is represented—the ridge falling on three sides and rising very abruptly on the fourth.

9. Contours forming rings, as at "E" and "F," denote either a hill-top or a crater, the latter being distinguished by lower numbered contours.

10. A saddle, col, pass or gap is readily distinguished on a contoured map by looking along the main ridge between hill tops; it is always marked by two pairs of contours lying opposite each other, one pair being a contour interval higher than the other. Thus, at "G," a pass over the main ridge is shown, the lower pair of contours (reference 180) lying to the north and the south of the pass while the upper set (reference 210) lies to the east and west of it.

11. Level ground is shown by the absence of contours.

The Vertical Contour Interval and the Horizontal Equivalent.

Bearing the foregoing in mind, we now come to the degree of slope indicated by the contours of a map.

The distance apart of these imaginary horizontal planes is called the *vertical interval* (V. I.) or *contour interval.* It is simply the vertical distance between contours.

The horizontal distance between the contours is called the horizontal equivalent (H. E.) of the slope represented.

Determining the Degree of Slope by a Scale of Horizontal Equivalents.

Many maps are furnished with a slope-scale or a scale of horizontal equivalents (Plate I., Fig. 2), by reference to which the slope at any point can be at once determined. Thus the slope at *E* is 12 degrees because the perpendicular distance between the contours at *E* is just equal to the horizontal equivalent for 12 degrees as shown by the scale.

A scale of horizontal equivalents is a series of map distances corresponding to the horizontal distances between contours on the ground for varying degrees of slope: thus, knowing that ground rises 1ft. vertically in a horizontal distance of 57.3 ft. when the slope is 1°, if 57.3 ft. be reduced to the scale of the map it must represent the distance between contours on a 1° slope when the contour planes are 1 ft. apart with the contour planes 30 ft. apart as in Plate 1 the distance would be 30 times as great. As hereafter explained, a horizon-

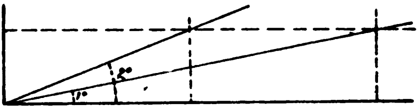
tal distance of half of 57.3 ft. between contours indicates a slope of 2°, and that of one-third of 57.3 ft. a slope of 3°, and so on; from which it is apparent that if each of these distances be reduced to the scale of the map they may be used for reference in determining the degree of slope of the ground represented on any part of the map. These distances form, as stated above, a scale of horizontal equivalents or a slope scale.

If, however, no scale of H. E.'s is given, then the degree of slope can be very readily determined from the V. I. and the scale of the map, as follows:

Determining the Degree of Slope by Gradients.

Slopes or gradients are sometimes represented by a fraction, as $\frac{1}{3}$, $\frac{1}{5}$, etc. (read 1 on 3 and 1 on 5), instead of a slope of "so many" degrees.

A grade of $\frac{1}{60}$ is so nearly equal to a 1° slope that it may be taken as such. By reference to the figure, it is apparent that if $\frac{1}{60}$ represents a slope of 1°, $\frac{1}{30}$ will represent a slope of 2°, because the rise is the same



in half the distance, that is, the ground must rise *twice* as quickly and the ascent be twice as steep. For a similar reason $\frac{1}{20}$ is the same as a 3° slope, $\frac{1}{15}$ as 4°, $\frac{1}{10}$ a 6°, and so on. From this it follows that gradients in the form of fractions can be transformed into slopes of a corresponding number of degrees by simply dividing 60 by the denominator of the fraction representing the gradient.

To apply this method of determining the slope at any point of the map, as *E*, proceed as follows:

From the scale of the map we find the distance between the contours at *E* to be 50 yards or 150 feet, and knowing that the vertical distance between them is 30 feet, it is evident that the gradient is $\frac{30}{150}$ or $\frac{1}{5}$, or that the degree of slope is $\frac{60}{5}$ or 12°.

In a similar manner the degree of slope at any point can be found.

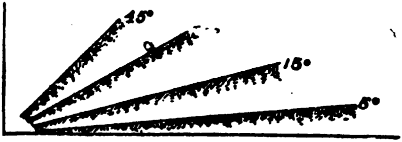
From the foregoing it is seen that contours not only show the *actual height* of points on the map, but also show the *shape* of the ground by their curves and the *steepness of slopes* by their distance apart.

The contours on a map are usually numbered

with their heights, "references," above some datum plane. If not numbered, the vertical interval is always given and they should be so numbered.

Slopes with Reference to Movements of Troops.

In a study of contoured maps and of corresponding slopes on the ground it is especially desirable to have a fair idea of what a 5-



or a 10-degree slope actually is and to know what effect the steepness of slopes has upon the movements of troops. The diagram shows slopes of 5°, 15°, 30° and 45°. It may be stated generally that slopes up to 15° admit of maneuvers for all arms; from 15° to 30° infantry can move in extended order, cavalry can move obliquely and artillery can not ascend; above 30° infantry alone can move, and that only with great difficulty; as the slope approaches 45° men can only climb with great danger of falling.

In the study of a contoured map proceed in the following order:

1. Examine the scale so as to get a general idea of the amount of country the map covers and the comparative distance on map and ground.

2. Note the direction of flow of the largest streams, since they occupy the lowest ground of the deepest valleys; this fact gives the key for numbering the contours in case they are not numbered.

3. Follow up the large streams and note their tributaries, thus locating the smaller valleys.

4. Water-sheds lying between the small valleys are next noted by observing their contours, which curve outward toward the main streams.

5. Next locate ridges, peaks, cols or saddles and spurs.

6. Note the average and the steepest gradients on the roads and near them.

An important consideration in map-reading is to decide whether troops at a certain part of the tract represented can be seen from a certain other part.

The Visibility of Points from Each Other on a Contoured Map.

The question of the visibility of points, one from another, depends upon the general concavity or convexity of the intervening ground. When contours are close together, the ground is steep; when they are farther apart, the slope is gentler; so that there is no difficulty in deciding as to a single slope, for we know that if the contours are closer together at the top than at the bottom the slope is concave, and if they are closer together at the bottom than at the top the slope is convex. In the first case the top and bottom of the hill are visible, the one from the other, while in the latter case they are hidden from each other. For example (Plate I., Figs. 1 and 2), *N* and *H* are mutually visible, while *A* and *P* are not.

The question of visibility is more difficult of solution, however, where the two points are some distance apart and a separate hill intervenes. Thus, can a detachment at *M* be seen from the camp at *K*?

The only information obtainable from a sketch such as Plate I., Fig. 1, is that the ridge *A* *may* in-

tercept the view. By reference to the contoured map (Plate I., Fig. 2), we can decide the question with certainty. For, the camp *K* being on the 30-foot contour, *A* is two contour intervals, 60 feet or 20 yards above it; the horizontal distance from *K* to *A* is 600 yards by the scale, hence the *inclination of the line of sight just touching the ridge at A* is $\frac{20}{600}=\frac{1}{30}=2°$. The reference of *M* is shown by the contours to be 150 feet or 50 yards above *K;* the horizontal distance from *K* to *M* is 1,000 yards, hence the *inclination of the line of sight from K to M* is $\frac{50}{1000}=\frac{1}{20}=3°$; therefore, we conclude that *A* does not hide *M*, or that *M* is visible from *K*.

Another method of solving this problem is by diagram as follows: Consider the "O" of the distance scale the location of the camp "K" and so mark it, then erect a perpendicular 20 yds in scale length at the 600 yd. point of the scale and mark its upper extremity "D", in like manner erect another 50 yds. in scale length at the 1000 yd. point of the scale and mark it "M": a straight line joining "K" and "M" will be seen not to touch the "D" line, hence the points "K" and "M" are intervisible.

In a similar manner one might make a complete outline of the surface of the ground from "K" to "M" by erecting at each point where the line KM crosses a contour a perpendicular of a scaled length equal to the elevation of the successive points above "K", then joining the tops of the perpendiculars by a curved line: the curved line would represent the surface of the ground cut by a vertical plane through "KM" and is called *a section through "KM".* In practice it is found more convenient to take some multiple of the vertical intervals, as 10, in order to facilitate the construction.

Other problems of a similar nature should be proposed and solved.

CHAPTER III.

Study of a Contoured Map on the Ground It Represents.

One of the most important *aids* in learning to read a map is to take the map into the field and actually study it with reference to the ground it represents.*

In order to do this intelligently, fasten the map to a piece of board and take it to some prominent point, as a hill top, from which a good view can be obtained.

Orienting the Map.

Lay the map on the ground and "orient" it, that is, place the map so that lines on it are parallel to the corresponding lines on the ground. This may be done in several ways.

1. *By means of the compass* (as already explained).

2. *Without the compass*, as follows:

(*a*) Suppose a distant point, as a church, is

*The contoured Geological and Coast Survey maps, on a scale of about 1 inch to 1 mile, answer very well for instruction in map-reading.

visible and you also find it shown on the map; then, if you can recognize on the map the point you occupy, all that is necessary in order to orient the map is to lay the edge of your ruler on these two points and revolve the map until the ruler is directed toward the distant point.

A rough modification of this method is to hold the map in the hands and with one thumb-nail on the plotted position of the occupied station and the other on that of the distant station, turn the map until both points are in line with the distant station.

(*b*) Another method of orienting the map, when you can place yourself between two prominent distant points which are plotted, is to place your ruler on the two plotted points and then revolve the board until the ruler sighted from each end is directed on the distant points. The simplest application of this method would be where one occupies a straight road shown on the map. In this case lay the ruler along the plotted road and by revolving the board sight the ruler along the road itself in either direction.

This method of orienting would apply equally

well if one were in *prolongation* of the line joining the two points instead of between the points.

Finding One's Place on the Map.

Suppose, however, you are unable to readily locate on the map the point you occupy on the ground; in other words, you are unable to "find your place on the map." Like orientation, this may be done with or without the compass, the process in surveying is called "resection."

1. *With the compass.*

(*a*) *When two distant visible points are plotted on the map.* In this case orient the map by the compass, then, without disturbing the board, stick a pin in the plotted position of one of the distant points, and, pivoting the ruler against the pin, point it toward this distant point and draw a line from the pin toward yourself. Proceed in the same manner with respect to the other point, and the intersection of these two lines will be the plotted position of your station.

(*b*) *When one distant visible point is plotted on the map and your position is partially defined by a road, telegraph line or other similar object.* In this case orient the map as before, and, pivoting the ruler

about the plotted position of the distant point, sight toward it and draw a line back until it intersects the defined line which you occupy. This intersection will fix your position on the map.

2. *Without the compass.*

(*a*) *When you are between two visible plotted points or in prolongation of the line joining them.* In either case orient by placing the ruler on the two points and shifting the board until the ruler is in line with the distant points. When oriented, select a third distant point, and, pivoting the ruler about its plotted position, point toward it and draw a line back until it intersects the line through the first two points. This intersection fixes your position on the map.

(*b*) *By "adjustment" with the aid of transparent paper.* In this case fasten a piece of transparent paper to any smooth surface and stick a pin into it to mark your position. Pivoting the ruler about the pin, point toward any distant object that is plotted on the map and draw a line from the pin outward. Without disturbing the pin or board, do the same, using two other points, after which place the paper on the map and adjust it until the

three lines pass through the plotted positions of the three points simultaneously. When this occurs, the pin-hole in the transparent paper will be directly over your position on the map.

It is to be noted that all methods of finding your place on the map, except the method by "adjustment," require the map to be first oriented.

Comparison of Map and Ground.

Having practiced the methods of orienting the map and finding your place on it, next compare the general lay of the land, the ridges, valleys, roads and woods with the map. Estimate distances and afterward check your estimates by reference to the scale of the map; then, by reference to the scale of slopes, practice judging of their steepness. At first nearly all overestimate the steepness of slopes, and nothing but practice will correct the tendency.

Advantage of Studying the Ground.

Aside from the value it is in itself, the study of ground and of maps in connection therewith is of the greatest advantage in training the eye to perceive and the mind to quickly grasp facts relating

to steepness of slopes and to cover for men under fire, which, in the excitement of action, might otherwise be neglected.

Aids to Map Reading.

One of the most useful aids in acquiring a knowledge of map reading is a sand model made to correspond to the map studied.

In this case the operations of measuring distances, angles and elevations and from them constructing a map are reversed in that the map is already made and the map reader constructs at a convenient scale a modeled landscape corresponding to the contoured map. A table having a 4-inch cleat around the edge and partially filled with clean sand has been found suitable for the purpose. A yard stick may be used for a scale of distances and a piece of wire for measuring vertical heights or contour intervals, the datum plane being coincident with the table top.

To a skillful map reader the map itself should convey as clear a picture to the mind as the sand model does to the eye.

PART II.

FIELD, OUTPOST AND ROAD SKETCHING.

CHAPTER IV.

Map-Reading a Preliminary to Map-Making.

After a careful study of Part I. on "Map-Reading," there will be very little difficulty in acquiring a useful, practical knowledge of elementary map-making.

The *making* of a contoured map does not come within the scope of elementary topography, although the *reading* of such a map does, so that contouring (except the roughest indication of heights and ridges by "form lines") will be omitted.

Very useful maps can, however, be made without resorting to contours, as will now be explained.

From Chapter I. we know that a map is a drawing of a limited tract of country made to scale,

on which objects are represented by conventional signs and from which their directions may be ascertained by reference to the meridian line or needle.

Field-Sketching—Two Methods of Locating Objects on a Proposed Map.

There are two ways of locating objects on a proposed map such as a field sketch.

1. By intersections from the ends of a base.
2. By traversing.

To make a map by the first method proceed as follows:

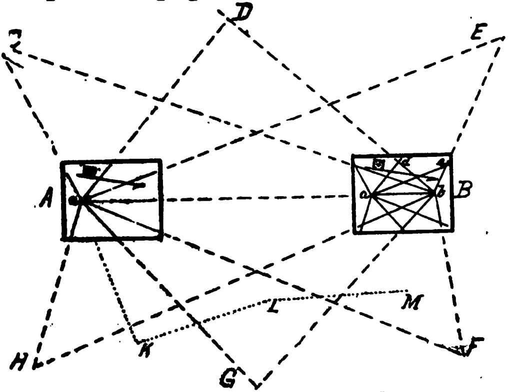
Locating Points by Intersection.

By *intersection* is meant the plotting on the map of points on the ground by means of sightings from

certain other points on the ground which have been previously plotted on the map.

The instruments necessary are a box compass, a drawing-board (about 10x14 inches), a ruler, pencil, rubber eraser, paper and half a dozen thumb tacks. A useful but not necessary addition consists of an improvised tripod made by tying three sticks together as shown in cut.

Go to the tract to be mapped, and, having decided upon a "scale" (which should be as large as the tract and paper will allow), construct it on a separate piece of paper.



Next examine the ground to be mapped and select a base-line, marking each end. This should

be as near the middle of the tract as possible, the points to be plotted, as well as the two ends, should be visible from each end, and, for good results, its length should be greater than half that of the tract.

Now, go to one end *A* of the base and place the board level on the tripod or ground, so that the longest dimension of the paper shall lie parallel to the longest dimension of the tract, as nearly as can be judged by eye.

Then place the compass on the board near one side, and turn the compass (not the board) until the arrow of the box comes opposite the north end of the needle, when a line (magnetic meridian) should be drawn along the edge of the box parallel to the needle. Mark the north end of this line with a half arrow-head on the side opposite the "true" north.

Without moving the board, assume a point *a* on the paper for the plotted position of this end of the base *A* and drive a pin into it; then, pivoting the ruler about the pin, point it toward the other end of the base and draw a line in that direction. Now, select objects (as *C*, *D*, *E*, etc.) which you

wish to plot, and, pivoting the ruler as before, draw indefinite straight lines toward them, writing the name of each object on its line.

Take the board to the other end *B* of the base, measuring its length as you go, and, with the scale, plot this length on the indefinite base-line already drawn, then drive a pin into this plotted point *b*, as was done in *a*.

Set the board over this end of the base, lay the ruler along the line representing it and turn the board until the *a* end of the ruler points toward the far end of the base; this "orients" the board. By placing the N.-S. edge of the compass box along the magnetic meridian the accuracy of the orientation may be checked.

Now, pivot the ruler about *b* and take sightings on the points previously selected, drawing indefinite lines toward them.

The intersections of corresponding lines locate these points on the map, and, to complete the map, there only remains to fill it in with the proper conventional signs and to add the scale.

It may be impracticable, owing to the size of the tract, or one's inability to see all parts of it from

the ends of the base to "fill in" the details without "traversing."

Locating Points by Traversing.

Traversing consists in observing the directions and measuring the lengths of a succession of straight lines on the ground.

Thus, suppose after locating the main points of the tract, as explained, it were found that certain details at *K*, *L* and *M* could not be seen from the base; it would then be necessary to resort to *traversing*, which in this case would consist in observing the directions and lengths of the lines *AK*, *KL* and *LM*.

The details of this operation would be carried out as follows:

Set up the board at *A*, as already described, orienting by the compass and by a sighting on *B*. Pivot the ruler about the pin driven into *a*, and sighting it on *K*, draw a line along it. Then carry the board to *K* and at the same time measure the direct distance to it by pacing or otherwise. From *a* lay off to scale along the last line drawn the distance *AK* and then set up the board at *K*.

Orient by placing the ruler on *ka* and turning the board until its *a* end points towards *A*. Then sketch in to scale the details at *K*, and, without disturbing the board, pivot the ruler on *k*, and, sighting it on *L*, draw a line along it. Next carry the board toward *L*, stopping to sketch in any important detail. To do this stop opposite the object and lay off to scale from *k* on the indefinite line *kL* the distance you have come; then estimate or measure the distance to the object, and, having oriented the board by eye, add the desired detail in its proper place. This method of locating objects on the map is known as that by *offsets*, by which are meant distances to objects off the traverse line taken on lines at right angles to this line. Now proceed toward *L*, being careful to commence counting where you left off; that is, *the count must be continuous between stations.**

Arriving at *L*, lay off from *K* the distance *KL* to scale, thus locating *l*; orient by a back sight on *K* and sketch details as before. Proceed in a similar manner to *M*, and finally, as a check, close on *B*: the

*The reason for this precaution is that the counting is more accurate than the plotting, so that, with a continuous count between *K* and *L*, we make but *one* error in plotting *L*; whereas, if the counting were not continuous, the location of *l* would be influenced by the errors accumulated in plotting the intermediate stations.

error of closure will, of course, show the accuracy with which the work has been done.

The map is now completed by adding the proper conventional sign for each feature, the scale and the legend (see Plate 2).

Plane Table Method of Field-Sketching.

The foregoing is the usual method of field-sketching; it is known as the *plane table method*, and for military work is the most valuable of all known methods.

Plane Table Methods Applied to Outpost-Sketching.

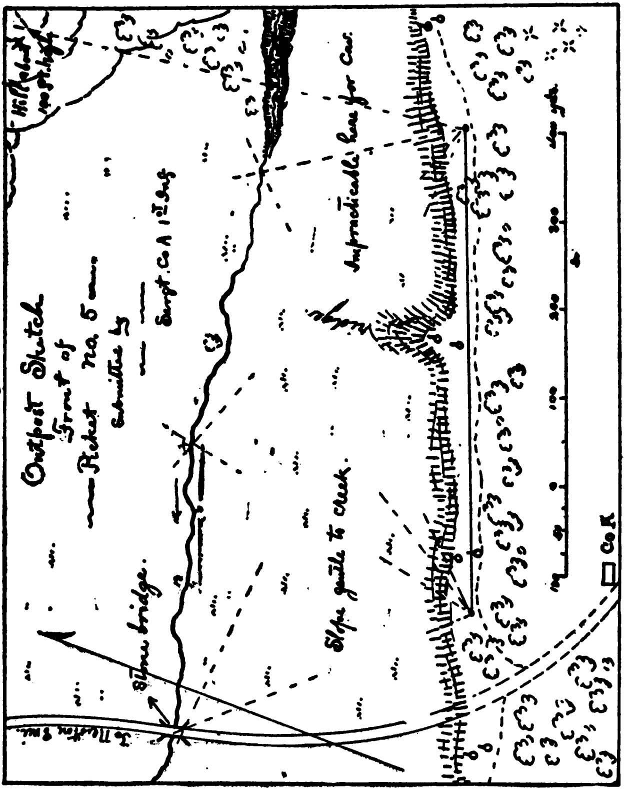
Outpost-sketching, by which is understood the rough field-sketching usually required to show the size and surroundings of the locality assigned to a picket, differs in the following points from the field-sketching described.

(*a*) It must usually be done more rapidly; hence it requires greater skill.

(*b*) The presence of an enemy's patrols would usually prevent traversing much beyond the line of sentries; hence the location of points in front of this line must be *wholly* by intersections.

The outpost-sketch (Plate 2) is made with the instruments described for field-sketching. The

base should be as far to the front as practicable, usually on the line of observation, and partic-



ular care should be taken to show roads (especially those coming from the enemy's direction), as well as woods, streams, bridges and gullies or other cover for an enemy.

Slopes in front should be described by writing a brief description on them—thus: "Steep; impracticable except for infantry," "Gentle and rolling," or "Rather steep; good cover for enemy."

The position of the picket should be shown on the map and the legend should state the number of the picket, so that the sketch may be identified by the outpost commander when he comes to combine it with those from the other picket posts.

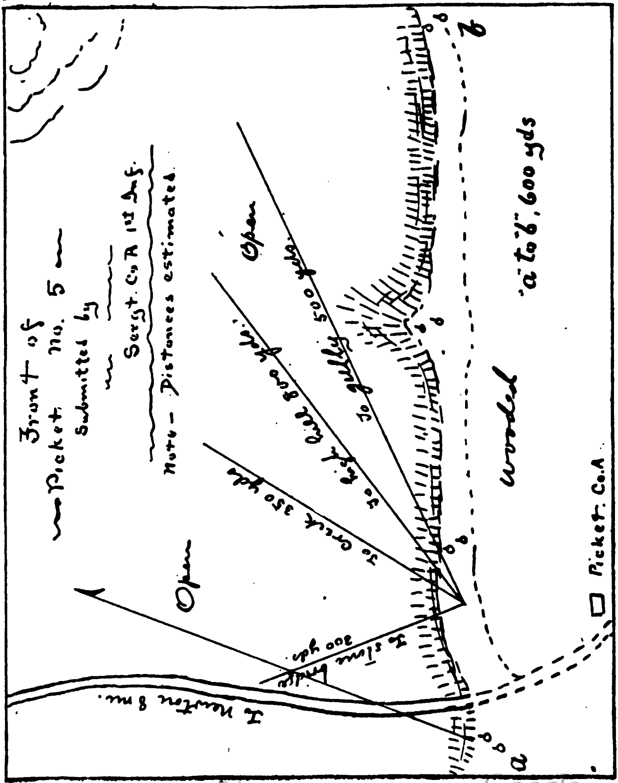
Makeshift for an Outpost Sketch.

Instances may arise when even this brief map would be impracticable, in which case a diagram such as is shown in Plate 3 is far more satisfactory than a verbal or even a written report.

The method of making the diagram is as follows:

Go to some prominent point on the line of observation, and, assuming a point on the paper as your position, lay the ruler on the paper, and,

without moving the latter, take sightings toward the various important points. Estimate the dis-



tance to them (or, better still, take it with a range-finder) and write it along the radiating lines as shown, then lay the compass on the paper and mark the meridian.

Use of Paper Ruled in Squares for Field-Sketching.

Field and outpost sketching is much facilitated by having the paper ruled in squares of ½ inch on a side. By assuming any convenient number of yards or paces as representing ½ inch, the paper affords a scale by which distances can be *read* without hesitation, as well as *laid off* by eye in directions parallel and perpendicular to the base. We can assume, for example, that ½ inch (the side of a square) is equal to 100 yards on the ground, or, if constructing the map by pacing, we might assume ½ inch as equal to 100 paces, and complete the map as already described. If the latter assumption is made, the completed map must also show a scale of yards, for a scale of paces alone conveys little or no information to a person reading the map. If the average 30-inch step were used, then, since ½ inch equals 100 paces, it equals 100x $\frac{5}{6}$ yards or 83.3 yards $\therefore$ 1 inch = 166.7 yards, and this last statement (that is, "Scale 1 inch =

166.7 yards") should appear on the map, or, better still, the usual form of scale (Chapter I.) should be constructed on the map.

Use of Form-Lines to Show Hills.

Much useful information with reference to hills can be conveyed in a sketch by means of "*form-lines.*" They are merely the *contour conventional sign* for hills and may be used instead of the *hachure sign* shown in Chapter I., which tends to obliterate other details of a map. The positions of ridges and knolls may be thus indicated by a few hastily drawn curves as in Plates 2 and 3.

CHAPTER V.

When a traverse of considerable length is to be made, especially when time is so limited that the work must be done mounted, the drawing-board with detachable ruler and compass is found to be very inconvenient.

The most usual form of traverse referred to is that known as a road or rapid reconnaissance sketch.

Description of Field Sketching Case.

The *Field (or Cavalry) Sketching Case* is the best instrument yet devised for this work. It consists of a board about 8½x10¼ inches in size having a head-piece, into which a compass is sunken flush with the board. On each side is a brass rod upon which the paper is rolled. The ruler consisting of two pieces of brass, is attached to the head-piece, and in the latest pattern (see cut), by acting as a pendulum, it allows the case to be used as a slope

board for ascertaining the steepness of slopes. Various scales are found on the ruler and on the head of the instrument. On or above the glass of the compass is marked a meridian line having an arrow-head or other indication at one end; the meridian line can be revolved independently of the

needle. To the back of the case is attached a strap for securing it to the left wrist. The entire instrument weighs about a pound and a half.

The cavalry sketching case has all the appara-

tus necessary for an instrument for field or outpost sketching for traversing and for contouring.

Methods of Using the Field Sketching Case.

To put the paper on the rollers. A strip of paper 3 or 4 feet long and about 7 inches wide is put on the rollers by first making a fold about $\frac{1}{8}$ of an inch wide at each end; then, with the case in front of the body, compass to the right, pass one end of the paper between the board and the far roller, bring it up outside and slip the fold of the paper into the slit of the roller. Turn the roller toward you, smoothing and guiding the paper until all but about one foot is wound up; then clamp the roller (unless it will hold by friction), and stretch a rubber band from the head of the case around this roller to prevent the paper from uncoiling. Proceeding in a similar manner, coil the short end of the paper on the near roller and wind it up until the paper lies smoothly on the board, then clamp the roller and remove the rubber band.

To set the working meridian. The instrument is so made that either the entire compass box or the meridian line on the glass can be turned in order

that the meridian on the sketch may be given such a direction with reference to the length of the paper that the traverse will lie near the middle line of the paper. This is called "setting the working meridian," and it is accomplished by facing in the general direction of the traverse, holding the case in front of the center of the body, compass to the right (normal position), and then, after the needle comes to rest, turning the compass box without deranging the case until the line on the glass comes over the needle, with the arrow over the north end of it. The working meridian is now set by clamping the compass box and must not be moved.

A meridian line is next drawn on the paper parallel to that on the glass and its north end marked. This operation of adjusting the working meridian and marking on the paper a meridian parallel to it accomplishes the same end that was reached in field-sketching (Chapter IV.) when the board was placed so that the longest dimension of the paper was made parallel to the longest dimension of the tract, the box compass placed on the board, turned until the arrow came opposite the north end of the

needle, and a meridian line was drawn along the edge of the box.

If the route to be followed is simply indicated on a completed map, the working meridian is set as follows: Lay the map on the ground, and, having marked on it a magnetic meridian (if one does not already exist), lay the sketching case on the map so that the longer dimension of the paper shall lie in the general direction of the traverse; then turn the working meridian until it is parallel to the magnetic meridian of the map, and it will be correctly set.

Field Work. Being at the first station and having adjusted the working meridian and marked a meridian line on the paper, face exactly toward the second station, loosen the set-screws of the ruler, level the case in front of the center of the neck, and then revolve it until the working meridian comes exactly over the needle, arrow-head over the north end. This orients the sketching case. The swinging of the needle may be checked by tilting the case slightly, but it must be nearly level and the needle free when the direction is finally taken. Next adjust the ruler on the paper so that one edge of it

passes through the assumed initial station and direct the other end on the second station, glancing at the working meridian to see that it is still over the needle and that the latter is free. If it is not over the needle, a slight turn of the wrist will bring it so. When satisfied with the sighting, hold the ruler firmly in place and tighten the set-screws, after which draw a line along the ruler's edge for the direction of the first course. Watching the needle and at the same time aligning the ruler on the object is at first hard to do, but practice soon removes the difficulty.

To take the directions of other objects from this station, face toward them, orient the case and proceed as in taking the direction of station 2.

Traversing toward the second station is now begun, stopping from time to time to locate details by offsets and to sketch them in, or at least note them in writing.

On reaching the second station, the first course is laid off to scale and the new station marked "2". The case is next oriented by revolving it until the working meridian comes over the needle, the arrow-head over the north end of it, when the direc-

tion of the next course is drawn as before, details in the vicinity sketched in and the work carried on in this manner to the end of the traverse.

As the sketch approaches the far side of the board, the paper is rolled from time to time on the near roller.

Method to be Followed when Traverse Runs off the Paper.

Should the traverse, either because of a change is its general direction or because the working meridian was not given a proper direction, run off the side of the paper, sketching is stopped there, and a line is drawn across the paper. The case is turned in the new general direction of the traverse, as was done on commencing, the working meridian on the glass turned until over the needle, thus changing it to suit the new direction, and a new meridian line drawn on the fresh portion of paper parallel to the new working meridian. The sketch is again commenced in the center of the paper about two inches above the line drawn, the new starting point being given the same number as the station where the sketch ran off the paper. If the running off was due to some *local* change of direc-

tion and the *general* direction of the traverse continues the same, the working meridian should remain unchanged.

When a change of working meridian becomes necessary, it is better, instead of changing it at the end of the course, to sketch an inch or more of the succeeding course; then draw a line across the paper, change the meridian as explained and start anew, giving the new starting-point the same number as the terminal point.

These changes of working meridian may have to be made several times, but the necessity therefor should be avoided, if possible, by proper arrangement of the working meridian.

Finishing the Sketch.

Only the smallest amount of sketching necessary to actually show distances, directions and details is done before the field-work is entirely finished. If it has been necessary to change the working meridian, or if the sketch has run off the paper without it having been necessary to change the meridian, we must, in either event, cut the paper across about an inch beyond where the

traverse ran off. The corresponding points of stopping and recommencing the sketch are made to coincide by sticking a pin through them into a board, the pieces are then turned until their meridian lines are parallel, when they are firmly pinned in this position and both cut through with a sharp knife, the cut passing through the coinciding points and as nearly perpendicular to the traverse as possible. The two pieces are then united by a strip of paper pasted on the back along the cut edges. When all are thus united, the traverse will follow along the middle of the irregularly shaped strip, which should then be made rectangular preparatory to putting in the conventional signs in colored pencil.

The scale and legend are finally added, the meridian made more conspicuous and the date and sketcher's name written at the bottom.

The "Road Report."

A *"road report"* is usually required with the road sketch and is attached to the lower right-hand corner of it. Its object is to furnish information not given by the sketch; a summary of the infor

mation required is found on the back of the blank report.

Suggestions as to Using Sketching Case.

Nothing but familiarity with the principles of plane table sketching and actual experience in the field with the sketching case can give a person a *practical* knowledge of road-sketching.

The following suggestions are the result of experience, and will be of advantage to beginners:

1. The scale, having been decided upon, should be constructed on a narrow strip of paper and pasted to the ruler, or kept upon a card, which should be tied to the person.

2. For mounted work have a scale of strides trotting and one of strides walking for the horse you use. A slow trot has been found to be the most uniform gait for the ordinary cavalry horse. The gallop is very unreliable.

3. For recording strides the most useful instrument known is the tallying register (see cut). With it each stride should be recorded as taken;

after practice, the impulse necessary to make the instrument record becomes almost involuntary.

4. Unless the "working meridian" can be clamped, there is always danger of its becoming accidentally shifted and thus ruining the sketch. Make a mark on the collar of the compass box, so that any change can be detected.

5. Learn to take all sightings mounted; it is more difficult at first, but will pay you in the end.

6. Tie pencil and rubber eraser to the person, so that they can not be dropped.

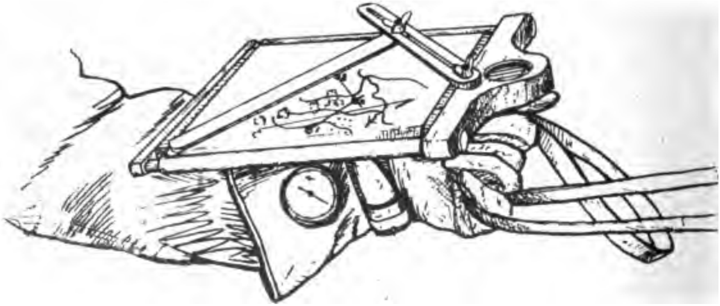
After practice with the cavalry sketching case, there is little difficulty in sketching fifteen miles of road and completing the map in a single day.

Details that a Road Sketch Should Show.

What to include in a road sketch **is a subject of**

much importance. At first the sketcher tries to depict more than the small scale on which the map is made will allow, and from this he is apt to go to the other extreme and not show objects of real military importance. As a rule, it may be stated that a road sketch and report should first of all show the construction, width and condition (in wet and in dry weather) of the *road.* It should also show all *bridges, streams, towns, camping-grounds, cross-roads, railroads* and *telegraph lines.*

Colored pencils are of great assistance in this class of work, for the color alone often renders conventional signs intelligible that would otherwise be obscure.



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